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CUSHIONING MATERIALS FOR HARVESTING AND HANDLING FRUITS AND VEGETABLES[1]

E. D. Schmidt and J. H. Levin[2]

Handling operations make up most of the steps in harvesting, grading, and packing of fruit crops. These operations may result in mechanical injury to fruit caused by impact from falls, change in the moving direction of fruits and vegetables on conveyor belts, and contact between fruit and container during transportation.

The use of cushioning material is important where mechanical tree shakers are used and fruit may fall as much as 15 to 18 feet. Equipment designers, packing house managers, and others select cushioning materials that are readily available. Tests of cushioning materials subjected to a free-falling object have not been available.

Cushioning material used to cover fruit-catching frames should have two important requirements: (a) It should absorb enough impact force to prevent the bruising of fruit, and (b) retain its cushioning ability long enough to justify the expense because rapid deterioration of the cushioning material through weathering can quickly make the material useless.

Some 150 samples of cushioning materials were obtained from 17 manufacturers for testing. The energy absorption, weathering characteristics, and costs were determined for 92 materials. Tests were not conducted on 58 samples because the materials were too rigid, lacked resilience, or otherwise were not suitable.

1/ Based on cooperative research by the Agricultural Engineering Research Division, Agricultural Research Service, U.S. Department of Agriculture, and the Agricultural Engineering Department, Michigan State University, East Lansing, Mich.

2/ Formerly agricultural engineer; and Leader, Fruit and Vegetable Harvesting Investigations, Agricultural Engineering Research Division, Agricultural Research Service, U.S. Department of Agriculture, East Lansing, Mich., respectively.

Acknowledgment is extended to Richard Wolthuis and Leland Fitzpatrick, Engineering Aids, Agricultural Research Service, U.S. Department of Agriculture, East Lansing, Mich., for construction of test equipment and help in conducting tests.

The cushioning material tested can be classified into five major groups: Urethane foam, vinyl, polystyrene foam, cellular polyethylene, and rubber. These materials were made up of the following types: Flexible urethane foam, polyvinyl chloride foam (closed cell), polyvinyl chloride foam (open cell), fused foam, latex foam, neoprene, expanded polystyrene, polyethylene, Ensolite[3], Thermobar[3], and experimental stock.

IMPACT TESTS

Apparatus

The equipment used for evaluating the cushioning materials' ability to absorb impact energy was developed by engineers of the U.S. Department of Agriculture at Michigan State University. The equipment consists of an automatic dropping mechanism that releases an object from any desired height up to 22 feet. The object falls freely inside a drop chute, past a series of phototubes, and onto a beam equipped with strain gages.

A detailed description of the apparatus is given in the work of E. D. Schmidt[4]. This equipment has been engineered to provide impact information when a falling object strikes the beam and rebounds before coming to rest. The difference in impact can be detected when balls weighing from 90 to 98 grams and differing in weight by 1 gram are dropped within the chute. The velocity recording system was used in studying terminal velocities[5].

Procedure

A 96-gram ball (3 inches in diameter) was dropped twice onto the beam from each of 20 different heights that ranged from 1 foot to 22 feet above the beam. These tests were immediately repeated so that the ball dropped onto the cushioning material. This was done for each of the 92 materials tested. An IBM 160 computer and an IBM 165 XY plotter were used to process and plot the graphs. A separate graph was plotted for each sample of cushioning material and contains two curves. The curve labeled "Beam" represents the impact of the dropped ball received by the beam without the cushioning material on it. The other curve shows the force transferred to beam with the cushioning material placed on it.

3/ Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

4/ Schmidt, E. D. Apparatus for dynamic evaluation of cushioning materials. Amer. Soc. Agr. Engin. Paper 62-322. 1962.

5/ Schmidt, E. D., and Levin, J. H. Terminal velocities of small fruits. U.S. Dept. Agr., ARS 42-89, 9 pp., illus. 1963.

The vertical axis of each graph is marked off by a relative scale in which 100 percent represents the maximum force received by the beam. The height from which the 96-gram ball was dropped is marked along the horizontal axis of each graph. The curves represent the maximum force transferred to the beam. The difference (gap) between the curves shows the force absorbed by the cushioning material or transferred into rebound energy. Since the maximum impact force transferred to the beam causes the mechanical injury to the moving object (fruit), the gap between the beam curve and material curve indicates the cushioning value of the material. Samples of several graphs are on pages 13 to 15. Graphs for any of the materials that were tested are available from the authors.

The relative effectiveness of each of ninety-two cushioning materials subjected to the impact of a ball falling from a height of 10 feet was calculated from the graphs and is shown in table 1.

IMPACT TESTS

Results

Material Type

The amount of cushion any type of material provides varies slightly due to lack of uniformity of the material. Materials also differ in manufacture, method of foaming, and density.

Urethane foam and polyvinyl chloride (open cell foam) transmitted less of the impact energy than any of the other materials tested. The impact force absorbed per 1/2-inch of thickness of cushioning material is shown in table 2. These data were derived by reducing the data in table 1 and calculating averages.

Material Thickness

The amount of cushioning of all materials except polyethylene increased directly as thickness of the material increased. For example, the average of the percentages of energy absorbed by the 1-inch thick urethane samples was 10.8 percent; for the 2-inch thickness, 23 percent; for 4-inch thickness, 46 percent. Polyethylene absorbed about 3.8 percent for any thickness above 1/2-inch. This may be due to the fact that most of the energy not transmitted to the beam by polyethylene goes into rebound energy and is not absorbed. Since the rebound energy remains more or less constant, the transmitted energy would stay about the same.

Table 1. Effectiveness of the cushioning materials when experimental ball is dropped from a height of 10 feet

Number	Manufacturer (experiment designation)	Material: Type	Material: Thickness	Material: Density	Maximum impact force absorbed[1/]
			inches	lbs/cu.ft.	percent
1	2	Urethane--------	4	1.93	46
2	7	Urethane--------	2	1.92	31
3	7	Urethane--------	2	1.53	30.5
4	7	Urethane--------	2	1.64	30.3
5	7	Urethane--------	1.5	1.69	28.3
6	2	Urethane--------	2	1.94	27.9
7	7	Urethane--------	2	2	27.8
8	6	Urethane--------	2	1.50	26.3
9	11	Urethane--------	2	1.39	26.2
10	7	Urethane--------	1.5	1.50	25.7
11	7	Urethane--------	1.5	1.71	25.7
12	12	Urethane--------	2	1.56	25.5
13	16	Urethane--------	2	1.27	24.6
14	8	Polyvinyl,oc[2/]--	2	5.24	23.2
15	13	Urethane--------	2	1.31	22.9
16	7	Urethane--------	1.5	1.94	20.6
17	9	Urethane--------	2	1.39	20
18	7	Urethane--------	1	1.70	18.9
19	7	Urethane--------	1	1.74	17.8
20	8	Polyvinyl,oc----	1.5	6	17.3
21	6	Urethane--------	1.5	1.48	17
22	9	Urethane--------	2	1.21	16.8
23	13	Urethane--------	2	1.35	16.6
24	7	Urethane--------	1	1.43	16.5
25	16	Urethane--------	1.625	1.36	16.4
26	14	Polyvinyl,oc----	2	6.10	16.1
27	11	Fused foam------	2	3.81	14.6
28	7	Urethane--------	1	1.86	13.3
29	8	Polyvinyl,oc----	1	5.47	13
30	13	Urethane--------	1.5	1.27	12.5
31	13	Urethane--------	1.875	1.29	12.3
32	9	Urethane--------[3/]	1	1.39	10.8
33	9	Polyvinyl,cc----	2.125	4.96	10.4
34	9	Latex foam------	2	7.08	10
35	3	Urethane--------	1	1.22	10
36	9	Urethane--------	1.5	1.22	9.2
37	6	Urethane--------	1	1.57	8.8
38	1	Polyvinyl,cc----	1	5.135	8.6
39	13	Urethane--------	1	1.32	8.5
40	15	Ensolite--------	2	4.84	8.4
41	13	Urethane--------	1.5	1.35	8.3
42	9	Latex foam------	1.75	6.5	7.8
43	14	Polyvinyl,oc----	1	7.71	7.8

44	7	Urethane--------	.5	1.66	7.7
45	6	Urethane--------	1	1.24	7.5
46	16	Urethane--------	1	1.29	7.5
47	13	Urethane--------	1.125	1.38	7.3
48	8	Polyvinyl,oc----	.5	6.35	7.1
49	15	Ensolite--------	1.75	4.07	6.9
50	9	Polyvinyl,cc----	1	5.92	6.7
51	9	Thermobar-------	1.125	5.77	6.7
52	7	Urethane--------	.5	1.88	6.7
53	9	Urethane--------	1.5	1.30	6.6
54	10	Polyvinyl,cc----	1.875	6.25	6.6
55	15	Ensolite--------	1.125	7.25	6.5
56	7	Urethane--------	.5	1.72	6.5
57	3	Urethane--------	1	1.38	6
58	2	Urethane--------	1	1.59	5.4
59	11	Fused foam------	1	3.30	5.4
60	15	Ensolite--------	1.625	7.13	5.2
61	7	Urethane--------	.5	1.42	4.9
62	15	Ensolite--------	1.125	7.56	4.4
63	10	Polyvinyl,cc----	1.5	7.16	4.2
64	9	Thermobar-------	.625	4.99	4.2
65	14	Polyvinyl,oc----	.5	5.69	4.1
66	1	Polyvinyl,cc----	.5	5.21	4.1
67	10	Neoprene--------	1.875	19.30	4
68	4	Polyethylene----	1	2.11	3.8
69	4	Polyethylene----	1.5	2.15	3.8
70	4	Polyethylene----	2	2.04	3.8
71	9	Latex foam------	1.125	6.42	3.8
72	9	Urethane--------	.875	1.26	3.6
73	14	Polyvinyl,oc----	.25	7.34	3.1
74	4	Polyethylene----	.5	2.29	3
75	6	Urethane--------	.5	1.59	3
76	11	Urethane--------	.5	----	2.9
77	9	Urethane--------	.5	1.44	2.4
78	13	Urethane--------	.5	1.25	2.3
79	15	Ensolite--------	1	4.65	2.3
80	10	Polyvinyl,cc----	.5	6.54	2.2
81	10	Polyvinyl,cc----	1	5.91	2.2
82	11	Fused foam------	.5	3.84	2.1
83	5	Polystyrene-----	.5	.973	2
84	16	Urethane--------	.5	1.20	1.6
85	10	Neoprene--------	.4375	27.90	1.5
86	13	Urethane--------	.5	1.22	1.5
87	15	Ensolite--------	.5	8.04	1.3
88	9	Polyvinyl,cc----	.5	4.02	.9
89	9	Urethane--------	.5	1.25	.9
90	15	Ensolite--------	.5	4.01	.78
91	10	Experimental----	1.125	5.90	--
92	15	Ensolite--------	.5	8.65	--

1/ Relative effectiveness of the cushioning material
2/ open cell
3/ closed cell

Table 2. Impact force absorbed per one-half inch thickness of each major type of cushioning material

Type of material	Impact absorbed per 1/2-inch of thickness: Average	Impact absorbed per 1/2-inch of thickness: Range
	Percent	Percent
Urethane	5.3	2 to 9
Polyvinyl, oc 1/	5.4	4 to 6
Polyvinyl, cc 2/	2.6	1 to 4
Fused foam	2.8	2 to 3
Latex foam	2.1	1.7 to 2.5
Ensolite	1.5	0 to 2
Thermobar	2.9	-----
Neoprene	1.3	-----
Polyethylene	3.8	-----
Polystyrene	2.0	-----

1/ open cell
2/ closed cell

Material Density

The density of urethane foam is a definite factor that affects the cushioning effect of the material. The higher the density, the greater the impact energy absorbed by the material. Urethane foam with a density of 1.2 to 1.3 lb/cu.ft. absorbs about 3.5 percent of the impact per half-inch thickness; that with a density of 1.3 to 1.4 absorbs about 4.2 per half-inch thickness; a density of 1.4 to 1.5, about 5.2 percent; a density of 1.5 to 1.6, about 6 percent; and densities of 1.6 to 2.0, about 7.5 percent (table 1).

Not enough data were obtained to determine the effect of density of the other materials.

IMPACT OF ENERGY

The energy of the falling ball used in the experiments can be calculated. The weight of the ball was 96 grams, the height of drop is known, and the approximate velocity of the ball at impact can be determined by the formula $V = \sqrt{2gh}$. The energy is transmitted to the beam, absorbed by the cushioning material, absorbed by the ball, and goes into rebound energy of the ball. The maximum impact force component of the transmitted energy is responsible for injury to the falling fruit. The date presented here may be an aid in predicting forces subjected to fruits that are approximately the same size and weight as the rubber ball used in the tests.

WEATHERING STUDIES

Procedure

A 6- by 4-inch sample of 142 materials of various thicknesses was attached to plywood frames and placed on the roof of the Agricultural Engineering Building, Michigan State University, East Lansing, Mich. The samples faced toward the south and were exposed to the weather for 92 days during the months of July, August, and September 1962. Table 3 shows conditions during this period.

Table 3. Weather during exposure tests of cushioning materials - 1962

Month	Rainfall	Average of possible sunshine	Temperature F. Average	Temperature F. Highest	Temperature F. Lowest
	Inches	Percent	Degree	Degree	Degree
July------	2.41	71	69.4	90	44
August----	1.85	76	69.5	90	42
September-	2.22	74	60.6	86	31

Results

Results of the weathering studies are shown in Table 4. They can be summarized as follows.

Table 4. -- Results of Weathering Tests

Number	Manufacturer (experiment designation)	Material: Type	Material: Thickness	Material: Color before exposure	Material: Color after exposure	Comments
			Inches			
1	1	Polyvinyl, cc	0.5	Tan	Orange	Slightly dry on exposed surface
2	1	Polyvinyl, cc	1	Tan	Orange	Do.
3	2	Urethane	1	White	Tan	1/4 inch disintegrated; bottom OK
4	2	Urethane	2	White	Tan	Do.
5	2	Urethane	4	White	Tan	Do.
6	3	Urethane	1	White	Tan	Do.
8	3	Urethane	1	White	Tan	Do.
9	4	Polyethylene	.5	White	Dirty	No change.
10	4	Polyethylene	1	White	Dirty	No change
11	4	Polyethylene	1.5	White	Dirty	No change
12	4	Polyethylene	2	White	Dirty	No change
13	5	Polystyrene	.5	White	Top burned	Singed and bumpy on top
18	6	Urethane	1	White	Top burned	1/5 inch disintegrated; bottom OK
19	6	Urethane	1.5	White	Tan	1/4 inch disintegrated; bottom OK
20	6	Urethane	2	White	Darker	Do.
21	6	Urethane	.5	White	Tan	3/10 inch disintegrated; bottom OK
22	6	Urethane	1	White	Tan	Do.
23	6	Urethane	1.5	----	----	---------------------------------
24	6	Urethane	2	White	Tan	2/5 inch disintegrated; bottom OK
25	7	Urethane	.5	Light gray	Darker	Exposed surface singed; no disintegration; bottom OK
26	7	Urethane	1	Light gray	Darker	Do.
27	7	Urethane	1.5	Light gray	Darker	Do.
28	7	Urethane	2	Light gray	Darker	Do.
29	7	Urethane	.5	Yellow	Burned	Do.
30	7	Urethane	1	Yellow	Burned	Do.
31	7	Urethane	1.5	Yellow	Burned	Do.
32	7	Urethane	2	Yellow	Burned	Do.
33	7	Urethane	.5	Pink	Tan outside	Do.
34	7	Urethane	1	Pink	Tan outside	Do.
35	7	Urethane	1.5	Pink	Tan outside	Do.
36	7	Urethane	2	Pink	Tan outside	Do.
37	7	Urethane	.5	White	Tan	1/16 inch disintegrated; bottom OK
38	7	Urethane	1	White	Tan	Do.
39	7	Urethane	1.5	White	Tan	1/8 inch disintegrated; bottom OK
40	7	Urethane	2	White	Tan	Do.
41	8	Polyvinyl, oc	.5	White	Burned brown	Burned and sticky on exposed surface
42	8	Polyvinyl, oc	1	White	Burned brown	Do.
43	8	Polyvinyl, oc	1.5	White	Burned brown	Do.
44	8	Polyvinyl, oc	2	White	Burned brown	---------------------------------
46	9	Latex foam	1.125	White	Yellow	Deterioration and formation of powder at exposed surface; bottom OK
47	9	Latex foam	2	White	Yellow	Do.
48	9	Latex foam	1.75	White	Yellow	Do.

49	9	Thermobar	.625	Tan	Tan	Curling; dried out; crumbling surface
51	9	Polyvinyl, cc	2.125	Brown	Brown	Little change
52	9	Polyvinyl, cc	.5	Cream	Cream	Do.
53	9	Polyvinyl, cc	1	Brown	Brown	Do.
54	9	Thermobar	1.25	Tan	Tan	Curling; dried out; crumbly surface
56	9	Urethane	.5	White	Tan	Nothing left
57	9	Urethane	.875	White	Tan	1/4 inch disintegrated; bottom OK
58	9	Urethane	1.5	White	Tan	3/8 inch disintegrated; bottom OK
59	9	Urethane	.5	White	Tan	1/4 inch disintegrated; bottom OK
60	9	Urethane	2	White	Tan	Do.
61	9	Urethane	2	White	Tan	3/8 inch disintegrated; bottom OK
62	9	Urethane	1.5	White	Tan	Do.
63	9	Urethane	1	White	Tan	Do.
66	10	Neoprene	.4375	Black	Black	No change
68	10	Neoprene	1.875	Black	Black	Do.
70	10	Polyvinyl, cc	.5	Cream	Darker	Buckled and dried outside; bottom OK
71	10	Polyvinyl, cc	1	Cream	Darker	Do.
72	10	Polyvinyl, cc	1.5	Cream	Darker	Exposed surface dried; splitting; bottom OK
73	10	Polyvinyl, cc	1.875	Cream	Darker	First 1/8 inch dried and shrunk
79	10	Experimental stock	1.125	Cream	Darker	Dried; shrunk; faded
81	11	Fused foam	.5	Light gray	Tan	Top 1/16 inch disintegrated; bumpy; burned; bottom OK
82	11	Fused foam	1	Light gray	Tan	Do.
83	11	Fused foam	1	Light gray	Tan	Do.
84	11	Urethane	2	White	Tan	1/4 inch disintegrated; bottom OK
85	11	Urethane	.5	White	Tan	1/8 inch disintegrated, bottom OK
93	12	Urethane	.625	Cream	Tan	1/4 inch disintegrated, bottom OK
95	12	Urethane	1.625	Cream	Tan	Do.
100	12	Urethane	2	White	Cream	3/8 inch disintegrated; bottom OK
105	13	Urethane	.5	White	Tan	1/4 inch disintegrated; bottom OK
106	13	Urethane	1.125	White	Tan	4/10 inch disintegrated; bottom OK
108	13	Urethane	2	White	Tan	3/10 inch disintegrated; bottom OK
109	13	Urethane	.5	White	Tan	2/10 inch disintegrated; bottom OK
111	13	Urethane	1.5	White	Tan	Do.
112	13	Urethane	1.875	White	Tan	3/10 inch disintegrated; bottom OK
113	13	Urethane	.5	White	Tan	3/10 inch disintegrated; almost nothing left
114	13	Urethane	1	White	Tan	2/10 inch disintegrated; bottom OK
115	13	Urethane	1.5	White	Tan	3/10 inch disintegrated; bottom OK
116	13	Urethane	2	White	Tan	Do.
117	14	Polyvinyl, oc	.25	White	Singed	Burned, sticky surface; bottom OK
118	14	Polyvinyl, oc	.5	White	Singed	Do.
119	14	Polyvinyl, oc	1	Pink	Pink	Do.
120	14	Polyvinyl, oc	2	White	Singed	Do.
128	15	Ensolite	.5	Cream	Burned	Surface singed; buckled.
129	15	Ensolite	1	Cream	Lighter	Surface singed; slightly buckled
130	15	Ensolite	1.75	Cream	Lighter	Dried on outside
131	15	Ensolite	2	Cream	Lighter	Do.
132	15	Ensolite	.5	Light tan	Bleached	Surface slightly dried
133	15	Ensolite	1.125	Light tan	Bleached	Do.
134	15	Ensolite	1.625	Light tan	Bleached	Do.
135	15	Ensolite	.5	Gray	Light gray	Surface dried and buckled
136	15	Ensolite	1.125	Gray	Light gray	Surface dried and slightly buckled
139	16	Urethane	.5	White	----	Nothing left
140	16	Urethane	1	White	Tan	3/10 inch disintegrated; bottom OK
141	16	Urethane	1.625	White	Tan	Do.
142	16	Urethane	2	White	Tan	Do.

Flexible urethane foam

With the exception of a series of pastel colored samples that remained intact, the first quarter of an inch of the urethane samples completely disintegrated. The top sixteenth of an inch of all these samples was in the process of drying to a powder. The bottom sections of the samples apparently maintained their strength and flexibility.

Polyvinyl chloride foam (closed cell)

The closed cell polyvinyl foam dried on the outside. The drying varied from a negligible amount that caused a slight change on the surface of the material to a larger amount characterized by a cracked crust and buckled pieces of material up to one inch thick. The amount of drying on the surface of the material varied with the manufacturer. Apparently, just the top of a piece of closed cell polyvinyl foam is effected when exposed to the elements.

Polyvinyl chloride foam (open cell)

The top quarter of an inch of the open cell polyvinyl foam became a burned, sticky mass. The bottom sections of the samples maintained strength and flexibility.

Fused foam

The top sixteenth of an inch of the fused foam samples had disintegrated, but the remaining part of the samples was not affected.

Latex foam

The top eighth of an inch of the samples of latex foam had dried out, cracked, and formed a crust that disintegrated when put under pressure. The bottom sections of the samples maintained their original strength and flexibility.

Ensolite

The effect of weathering upon samples up to one inch thick ranged from slight drying on the exposed surface to the formation of a thin crust and buckling of the material. A loss in flexibility was apparent in the samples that had buckled. The surfaces of the samples over one inch thick had dried, but the samples had neither buckled nor lost flexibility.

Experimental stock

The experimental stock dried out, buckled, and shrank. Shrinkage amounted to approximately an eighth of an inch for a 1/2-inch thickness of material. The bottom half of the material maintained its flexibility.

Neoprene

The neoprene samples were not affected.

Thermobar

The samples of Thermobar dried out and curled badly. The top surface crumbled. Only pieces of material up to one inch thick were tested.

Expanded Polystyrene

The exposed surface was slightly singed. Singeing had a slight hardening effect on the surfaces.

Polyethylene

The polyethylene samples were not affected.

COST OF MATERIALS

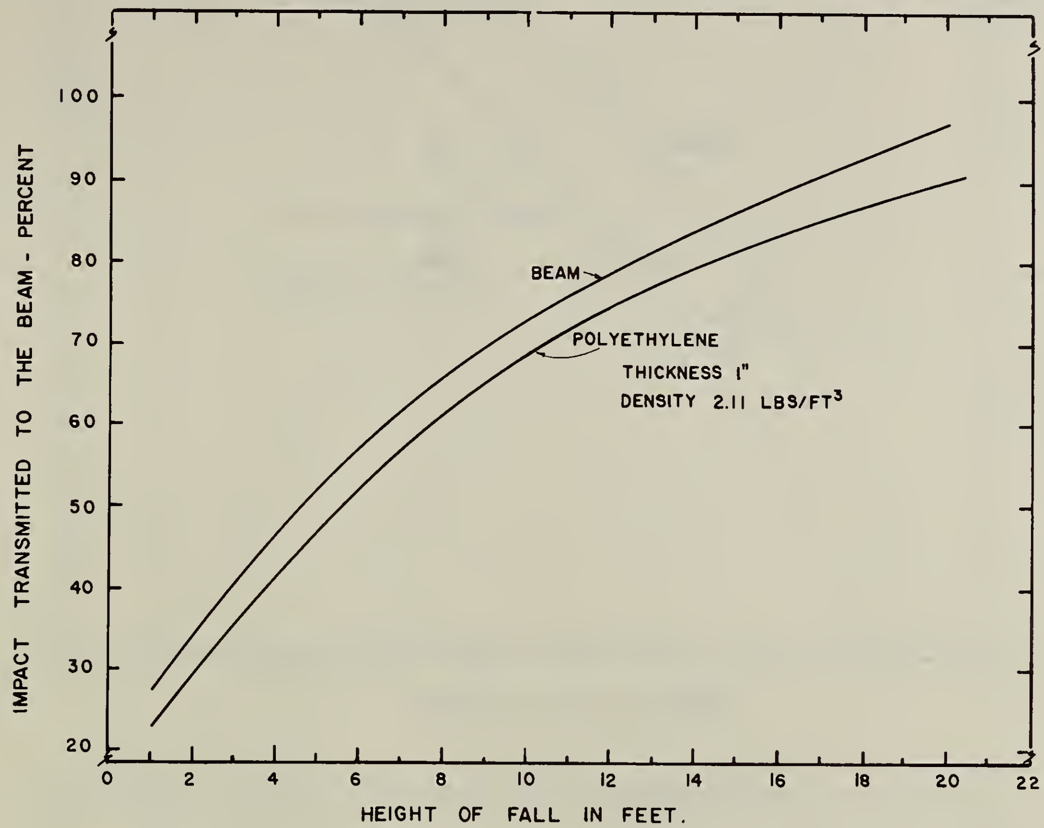
During the summer of 1963, all manufacturers were asked to quote prices. Quotations for the same types of cushioning material from the various manufacturers differ because of density and thickness of the material and the quantity of material ordered. For example, a sheet of urethane one-half of an inch thick may cost almost as much as a sheet one-inch thick because labor used in slicing off the sheet is as great an item as is the cost of the material. Urethane of 2.0 density may cost twice as much per unit as urethane of 1.4 density. The price per square foot of eight cushioning materials one-inch thick received from sixteen manufacturers are tabulated as follows:

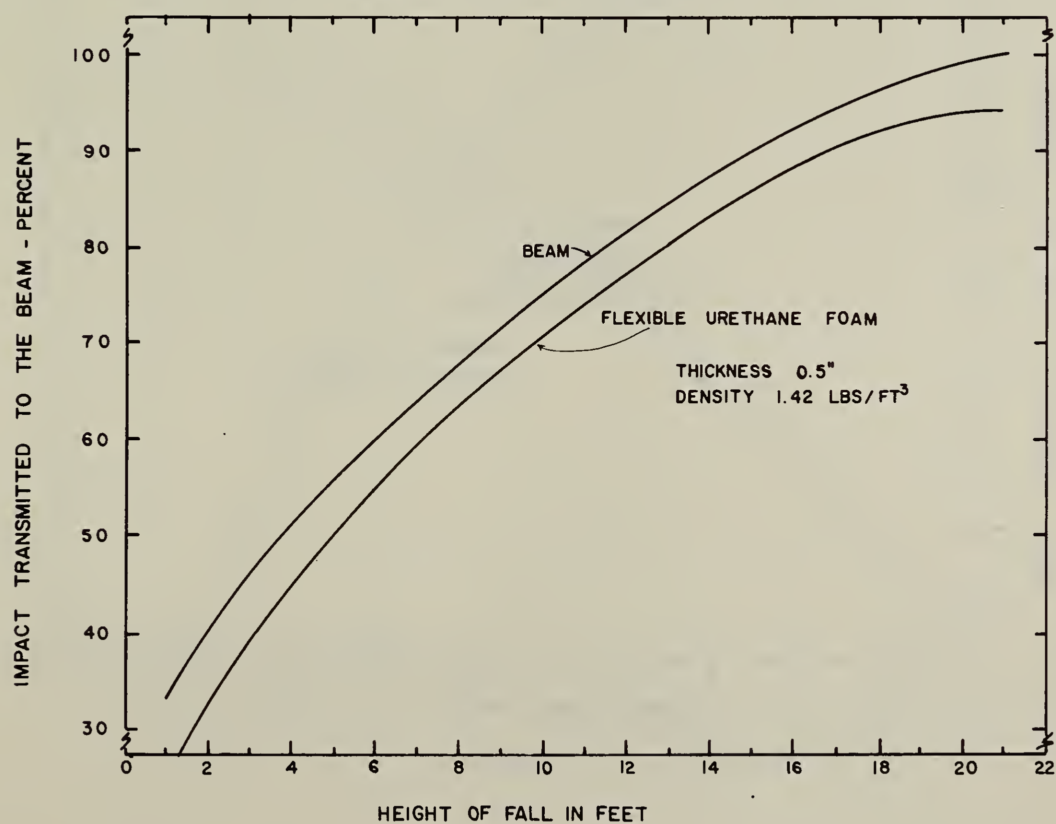
Type of Material	Cents
Flexible urethane foam	11 to 24
Polystyrene	15 to 22
Neoprene	96 to 124
Polyvinyl chloride foam (closed cell)	36 to 96
Ensolite	74 to 101
Polyethylene	27 to 48
Polyvinyl chloride foam (open cell)	48
Latex foam	57 to 82

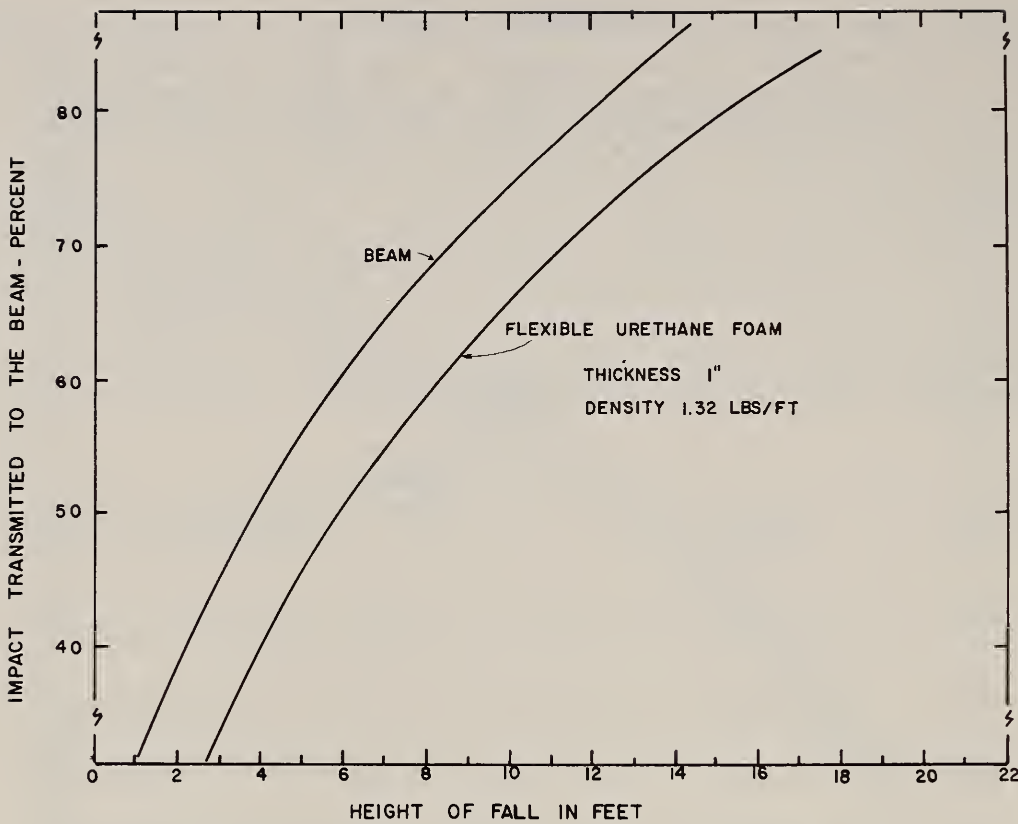
SELECTION OF MATERIAL

Selection of a cushioning material requires the consideration of the amount of cushioning required, the cost, and the durability of the material. No one material is best for all conditions. The data presented in this report and information that is available from manufacturers should be helpful in selecting cushioning materials.

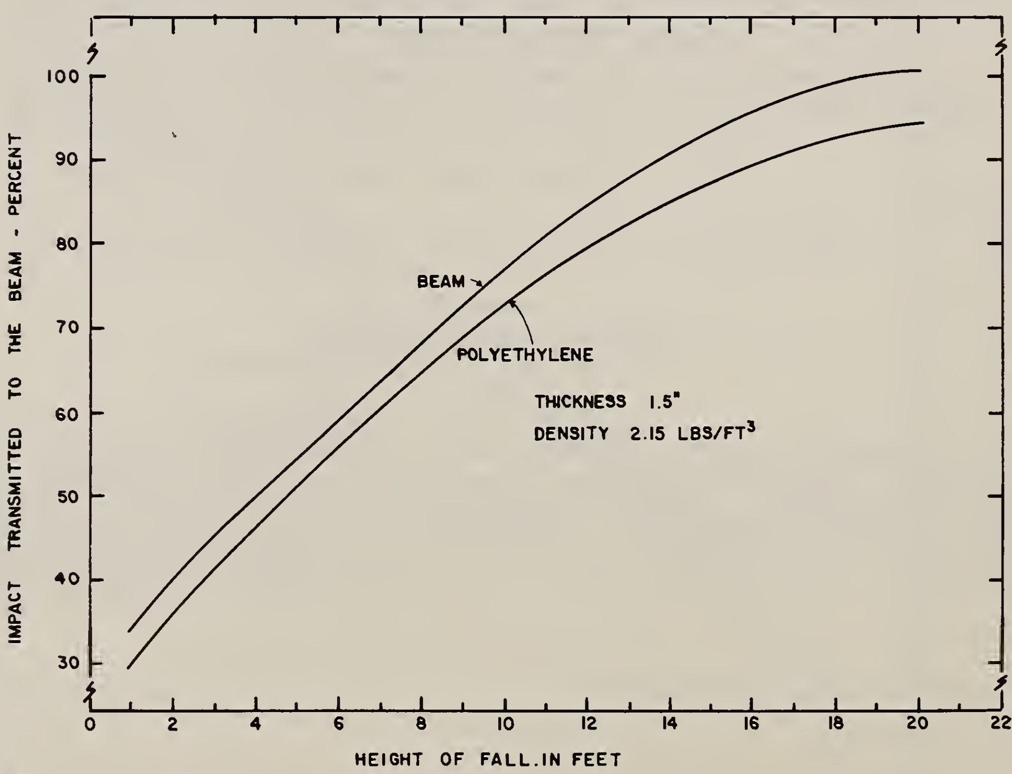
The graphs that follow were prepared from tests on flexible urethane foam, polyethylene, and ensolite and are examples of graphs available from the authors for all cushioning materials they tested in this experiment.



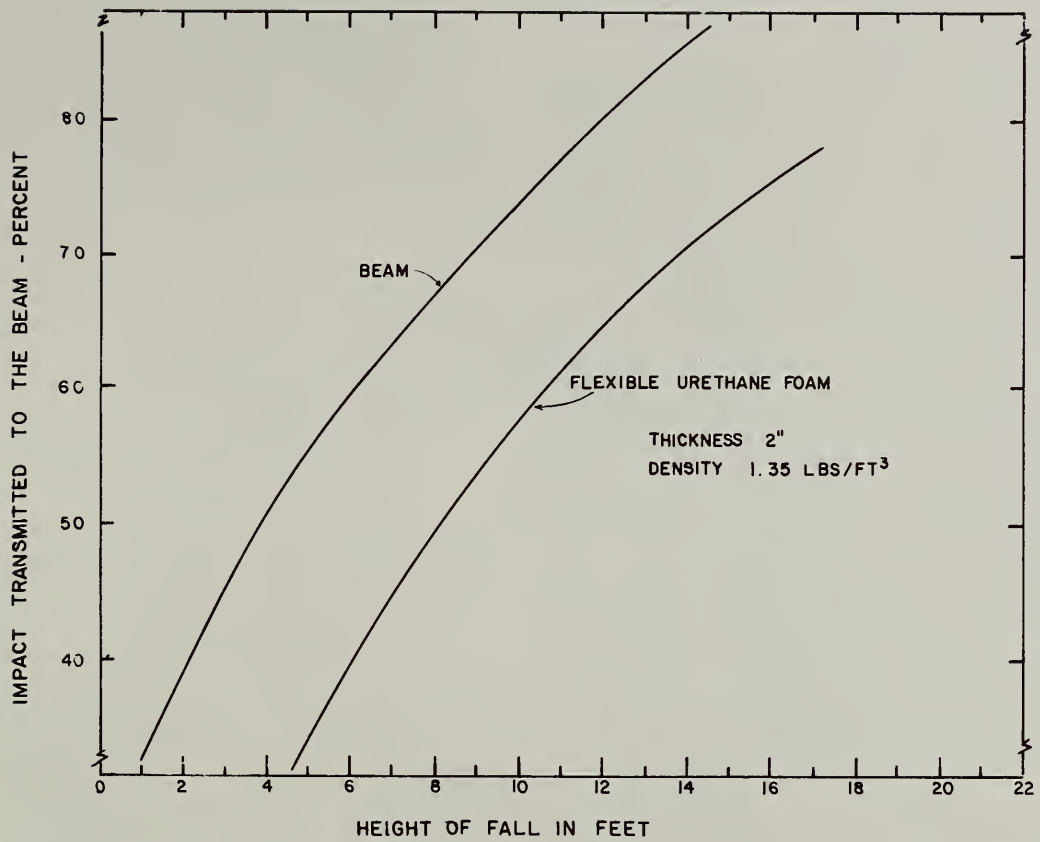


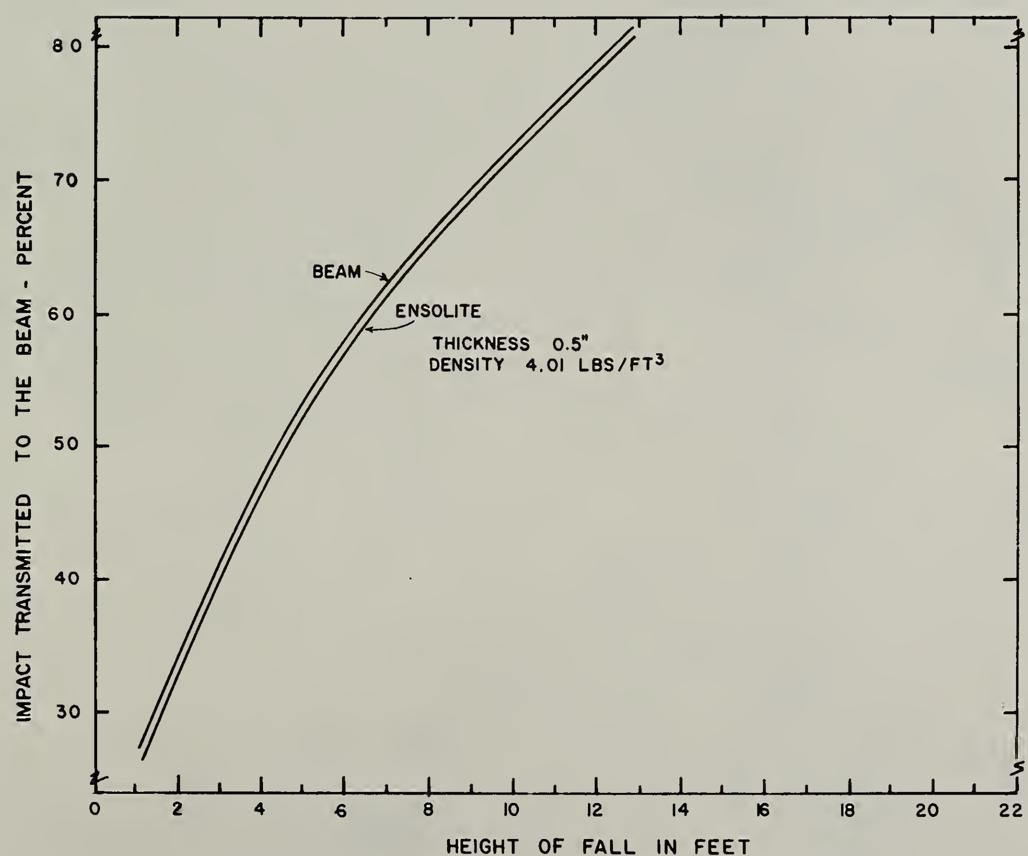


IMPACT TRANSMITTED TO THE BEAM - PERCENT
HEIGHT OF FALL IN FEET
BEAM
FLEXIBLE URETHANE FOAM
THICKNESS 1"
DENSITY 1.32 LBS/FT



IMPACT TRANSMITTED TO THE BEAM - PERCENT
HEIGHT OF FALL.IN FEET
BEAM
POLYETHYLENE
THICKNESS 1.5"
DENSITY 2.15 LBS/FT^3


IMPACT TRANSMITTED TO THE BEAM - PERCENT
HEIGHT OF FALL IN FEET
BEAM
FLEXIBLE URETHANE FOAM
THICKNESS 2"
DENSITY 1.35 LBS/FT3
40
50
60
70
80
0
2
4
6
8
10
12
14
16
18
20
22


IMPACT TRANSMITTED TO THE BEAM - PERCENT
HEIGHT OF FALL IN FEET
BEAM
ENSOLITE
THICKNESS 0.5"
DENSITY 4.01 LBS/FT3
30
40
50
60
70
80
0
2
4
6
8
10
12
14
16
18
20
22